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FOREST RESEARCH REPORT

No. 34 January, 1992

WORKER PRODUCTIVITY IN PRECOMMERCIAL THINNINGS

INTRODUCTION

Precommercial thinning is a spacing operation intended to increase the proportion of preferred species and shorten the time to operability of dense naturally regenerated stands. This is accomplished by cutting the less desirable trees, thereby promoting the growth and quality of crop trees. Other benefits of this treatment may include the development of a windfirm stand due to larger root systems, an increase in site quality and a decrease in harvesting costs (Piene and Anderson, 1987).

In Nova Scotia, stands eligible for precommercial thinning must be at least 60% stocked with a minimum of 4,000 trees/ha and have an average height between 1.5 and 9.0 metres. Between 1966 and 1990, over 71,600 hectares were precommercially thinned in Nova Scotia.

The purpose of this study is to quantify worker productivity attained in precommercial thinnings and its' relationship to various stand, site, and climatic factors. This is one in a series of silviculture worker-productivity studies (NSDLF, 1989, 1991, NSDNR, 1991, 1992).

STAND DESCRIPTIONS AND TREATMENT

Twenty stands meeting the criteria for a precommercial thinning operation were identified and forty-two blocks with uniform site and stand conditions within these stands were designated for the study. Site and stand characteristics capable of affecting worker productivity were recorded (Appendix I). Before treatment, the blocks varied as follows:

(i) 7,436 to 42,748 trees/ha (average 21,333 trees/ha),

(ii) crop tree height 2.43 to 8.50 m (average 4.63 m),

(iii) softwood density 5,595 to 41,281 trees/ha (average 19,221 trees/ha),

(iv) hardwood density 0 to 10,072 trees/ha (average 2,112 trees/ha).

Canada

Nova Scotia

The stands were spaced according to guidelines in the Nova Scotia Department of Lands and Forests, Forestry Field Handbook (NSDLF, 1988). The operations were performed with chainsaws between February, 1987 and November, 1989. Twenty-two blocks were spaced by 5 forestry instructors from the Commercial Saftey College in Masstown, Nova Scotia and the remaining 20 blocks by woods workers of "average experience".

DATA COLLECTION AND ANALYSIS

Fixed interval activity sampling (Stjernberg, 1991) was used to determine the relative amount of time spent on various activities by each worker. The activities being executed by the worker (such as felling, limbing, or saw maintenance) were noted every 30 seconds. The activities were grouped as either productive or non-productive (Appendix II). Productive man hours (PMH) were calculated by multiplying the percentage of productive activity occurrences by the total time to thin the block. On average, each block was observed for 3 hours and 25 minutes out of a total thinning time of 10 hours and 51 minutes. These observations were taken at intermittent periods spread throughout each sampled work day. This resulted in an average of 410 activity samples per block (Appendix I).

RESULTS AND DISCUSSION

Activities

The time spent on productive activities was 82% and non- productive 18% (Table 1). Of the productive activities, felling trees took the most time (58%) followed by moving (13%), felling preparation and freeing hung-up trees (9% each), other productive activities (7%) and limbing and slashing (4%). Saw maintenance was the most time consuming non-productive activity, (55%), followed by breaks (31%), saw repair (11%), and other non-productive (3%).

Table 1. Percent of time spent on productive and non-productive precommercial thinning activities.

Activities	Percent of		
	Total Time	Productive Time	Non-productive Time
PRODUCTIVE			
Felling Preparation	7	9	-
Felling	48	58	-
Freeing Hung-up Trees	7	9	-
Limbing and Slashing	3	4	-
Moving	11	13	-
Other	6	7	-
Total Productive	**82**	**100**	-
NON-PRODUCTIVE			
Breaks	6	-	31
Saw Maintenance	9	-	55
Saw Repair	2	-	11
Other	1	-	3
Total Non-Productive	**18**	-	**100**

Productivity

In this study, worker productivity varied by over 400%, from a low of 0.018 hectares precommercially thinned per productive man hour (ha/PMH), to a high of 0.103 ha/PMH. Productivity averaged 0.045 ha/PMH or 0.258 ha/day assuming 5.74 productive hours per day (82% of a 7 hour work day excluding lunch).

The following model was used to relate productivity to stand density:

$$P = B_0 * SD^{B1}$$

where, P = Productivity expressed as hectares thinned per productive man hour,
B_n = Regression coefficients,
SD = Pre-treatment density (trees/ha) of all regeneration taller than 30 cm.

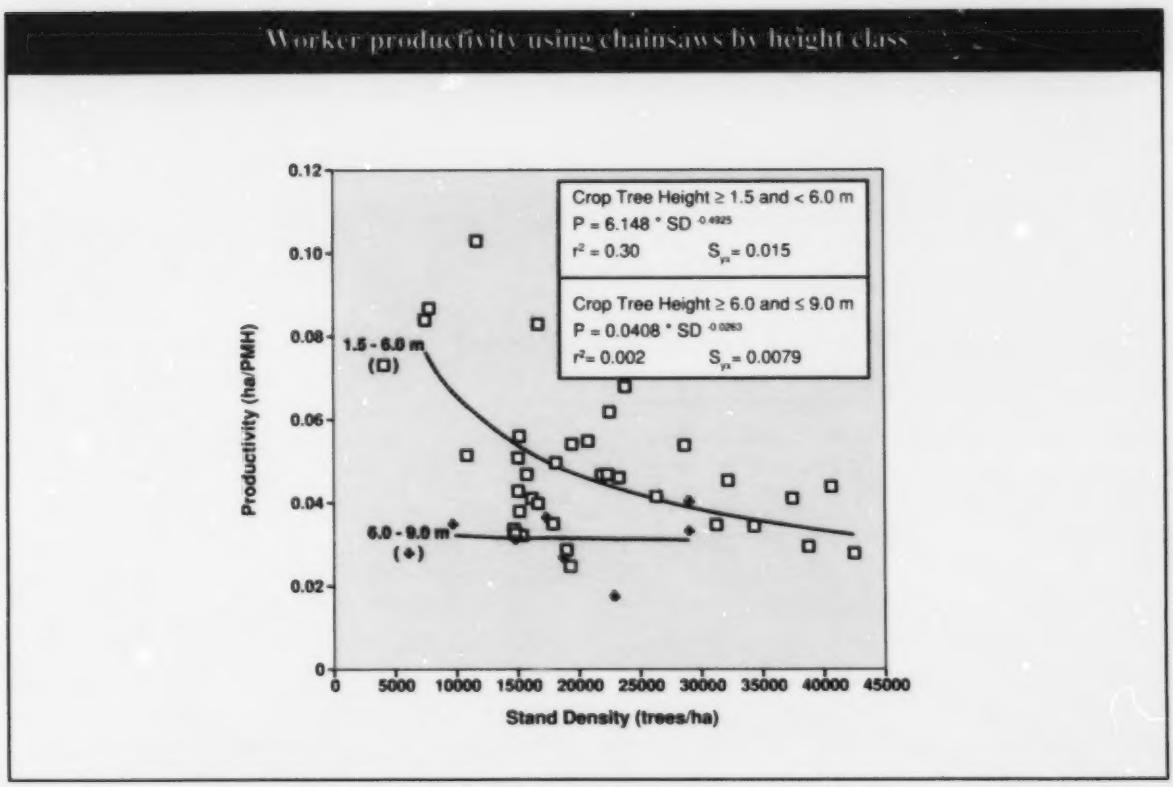

Figure 1. Predicted (P) and actual productivity in hectares per productive man hour (PMH) versus stand density (SD; trees/ha) and crop tree height prior to treatment.

Table 2. Predicted precommercial thinning productivity based on stand density and crop tree height.

Stand Density		Productivity			
		Crop tree height ≥ 1.5 and < 6.0 m		Crop tree height ≥ 6.0 and ≤ 9.0 m	
trees/ha	trees/ac	ha/day[1]	ac/day	ha/day	ac/day
5000	2023	0.532	1.315	0.187	0.462
7500	3035	0.436	1.077	0.185	0.457
10000	4047	0.378	0.935	0.184	0.454
12500	5059	0.339	0.837	0.183	0.451
15000	6070	0.310	0.766	0.182	0.449
17500	7082	0.287	0.710	0.181	0.447
20000	8094	0.269	0.664	0.180	0.446
22500	9105	0.254	0.627	0.180	0.444
25000	10117	0.241	0.595	0.179	0.443
27500	11129	0.230	0.568	0.179	0.442
30000	12141	0.220	0.544	0.178	0.441
32500	13152	0.212	0.523	-	-
35000	14164	0.204	0.504	-	-
37500	15176	0.197	0.488	-	-
40000	16187	0.191	0.472	-	-
42500	17199	0.186	0.458	-	-
45000	18211	0.180	0.446	-	-
47500	19223	0.176	0.434	-	-
50000	20234	0.171	0.423	-	-

[1]One day is based on 5.74 productive man hours (82% of a 7 hour work day, excluding lunch).
Shaded numbers are outside the range of collected data.

Two regression equations were derived from this model, one for the shorter stands (average height of 1.5 to 6.0 m tall; 35 cases) and one for the taller stands (average height of 6.0 - 9.0 m tall; 7 cases) (Figure 1 and Table 2).

For the shorter stands, worker productivity increases at an accelerating rate as stand density decreases. For example, in high density stands, productivity is only 7% higher for stands with 35,000 as compared to 40,000 trees/hectare. However, for a decrease of 5,000 trees per hectare in lower density stands (7,500 instead of 12,500), productivity is 29% higher (Figure 1, Table 2). In taller stands, productivity is not strongly affected by density. For example, for a decrease of 20,000 trees from a stand density of 30,000 to 10,000 trees per hectare, productivity increases by only 3%.

Increased crop tree height has a negative effect on production. For the taller stands, productivity is predicted to be 41% and 19% less than in the shorter stands for densities of 10,000 and 30,000 respectively (Figure 1, Table 2).

No strong correlations were found between productivity and the other variables measured (Appendix I).

CHAINSAW VERSUS BRUSHSAW

In Nova Scotia, the chainsaw is the most widely available tool for performing precommercial thinnings on small private holdings. This is attributed to the high cost and limited versatility of brushsaws as opposed to chainsaws in implementing a wide variety of forest management treatments (Eddy, 1987). On the other hand, large landowners in Nova Scotia and in countries like Sweden (Berglund 1987) prefer the brushsaw over the chainsaw. The brushsaw is considered safer to operate and easier on the operator because of less bending. In addition, Ellingsen (1978) produced figures which show that, in the hands of professional workers, brushsaws are capable of producing at least 50% more than chainsaws.

Comparing the data collected for chainsaws in this study with Stora Forest Industries[1] brushsaw data (unpublished), reinforces Ellingsen's conclusions (Figure 2, Table 3). For any given stand density, worker productivity using brushsaws is higher than that for chainsaws. The magnitude of the difference is greatest at the lowest densities and least at the the highest densities. For example, in a stand with a density of 12,500 trees per hectare, brushsaws out perform the chainsaws by 83%. At 40,000 stems/ha, the difference in productivity is 61%.

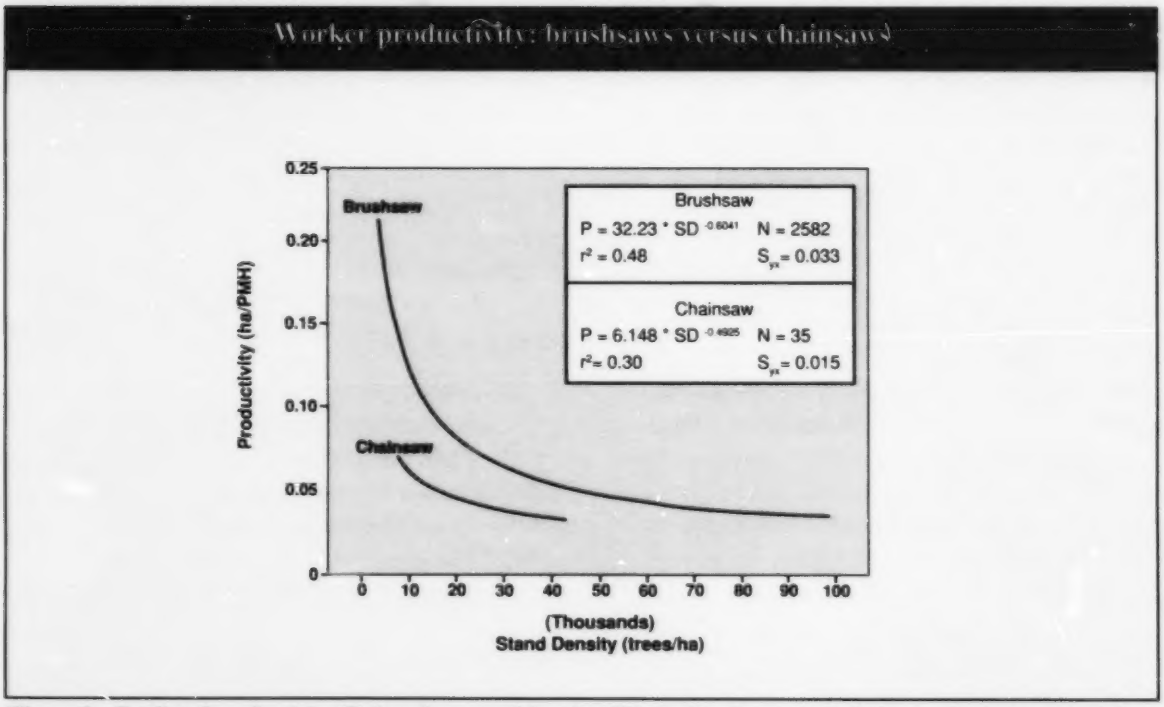

Figure 2. Predicted productivity (P) based on stand density (SD) for brushsaws and chainsaws in precommercial thinnings for stands <6.0m tall. Brushsaw data obtained from Stora Forest Industries. Chainsaw data derived from this study.

[1]Only the stands in the shorter height class (≥1.5 and < 6.0m) from this study were compared, since the Stora data was gathered in stands less than 6.0 m in height.

Table 3. — Comparison of predicted productivities between brushsaws and chainsaws for stands < 6.0 m in average crop tree height.

Stand Density (trees/ha)	Productivity (ha/PMH[1])		Difference brushsaw-chainsaw)	
	Brushsaw[2]	Chainsaw[3]	(ha/PMH)	(%)
5000	0.188	0.093	0.095	103
7500	0.147	0.076	0.071	94
10000	0.124	0.066	0.058	87
12500	0.108	0.059	0.049	83
15000	0.097	0.054	0.043	79
17500	0.088	0.050	0.038	76
20000	0.081	0.047	0.034	73
22500	0.076	0.044	0.031	71
25000	0.071	0.042	0.029	69
27500	0.067	0.040	0.027	67
30000	0.064	0.038	0.025	66
32500	0.061	0.037	0.024	64
35000	0.058	0.036	0.022	63
37500	0.056	0.034	0.021	62
40000	0.053	0.033	0.020	61
42500	0.052	0.032	0.019	59
45000	0.050	0.031	0.018	58

[1]ha/PMH = hectares per productive man hour.
[2]Brushsaw = Based on an equation derived from Stora Forest Industries data for stands <6.0 m: $P = 32.23 * SD^{-0.6041}$
[3]Chainsaw = Based on an equation derived from data in the shorter height classes (≥1.5 and <6.0 m) in this study: $P = 6.148 * SD^{-0.4925}$
Shaded numbers are outside the range of collected data.

SUMMARY AND CONCLUSIONS

The major results of this study to determine worker productivity in precommercial thinning treatments are as follows:

1. Productivity averaged 0.258 and ranged from 0.103 to 0.591 ha/day for blocks varying in density from 7,436 to 42,748 stems/ha and crop tree height between 2.43 and 8.50 m (assumes 5.74 productive hours per day).

2. Workers spent 82% of their time on productive activities. The most time consuming productive activity was felling (48%) while the most time consuming non-productive activity was saw maintenance (9%).

3. Worker productivity (P) expressed in hectares per productive man hour (ha/PMH) is related to stand density (SD; trees per hectare) according to the following regression equations:
For stands with an average crop tree height of ≥ 1.5 and < 6.0 m:

$$P = 6.15 * SD^{-0.493} \quad [1]$$

For stands with an average crop tree height of ≥ 6.0 and ≤ 9.0 m:

$$P = 0.041 * SD^{-0.026} \quad [2]$$

4. Initial stand density strongly influences worker productivity in the shorter stands (1.5 to 6.0 m). For example, productivity is approximately 71% higher in stands with 10,000 versus 30,000 trees/ha (Equation [1]). In the taller stands, initial stand density does not greatly influence worker productivity. For stand densities of 10,000 and 30,000 trees/ha, worker productivity varied by less than 3% (Equation [2]).

5. Productivity in the shorter stands compared to the taller stands is predicted to be 19 to 53% higher for densities of 30,000 and 10,000 trees/ha respectively.

6. Workers can potentially increase their productivity by 50 to 100% by using brushsaws instead of chainsaws.

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APPENDIX I

Block values prior to treatment and productivity.

Block	Prod[1] (ha/PMH)	Area (ha)	Temp[2] (°C)	Hist[3] (code)	Softwood			Hardwood			Stand Density[4] (trees/ha)	Crop Tree Height (m)	Height of first limb (%)		Operator[5]	Observations[6] (number)
					Density[4]		Height (m)	Density[4]		Height (m)			0-10 (cm)	10+(cm)		
					(trees/ha)	(%)		(trees/ha)	(%)							
1	.018	0.25	-8	1	22540	98	ND[7]	460	2	ND	23000	8.50	0	100	1	602
2	.025	0.26	15	1	17745	91	ND	1755	9	ND	19500	4.29	0	100	5	357
3	.027	0.19	-8	1	18800	100	ND	0	0	ND	18800	7.57	0	100	2	200
4	.028	0.30	16	1	41281	97	4.13	1467	3	4.31	42748	5.13	2	98	16	361
5	.029	0.31	24	2	15617	82	2.05	3531	18	3.25	19148	2.63	12	88	19	480
6	.029	0.47	22	2	36838	95	2.67	2122	5	4.00	38960	4.00	3	97	20	480
7	.031	0.20	-6	1	14250	95	ND	750	5	ND	15000	7.82	0	100	1	136
8	.032	0.13	18	1	12069	81	ND	2831	19	ND	14900	3.65	30	70	2	179
9	.033	0.28	15	1	12710	82	ND	2790	18	ND	15500	4.32	0	100	4	355
10	.033	0.35	16	1	26211	90	6.21	2934	10	5.69	29145	7.50	1	99	14	240
11	.034	0.31	19	3	14622	99	4.00	149	1	ND	14772	4.13	0	100	13	536
12	.034	0.31	19	3	33870	98	3.00	597	2	0.85	34467	3.63	1	100	12	600
13	.035	0.20	-6	1	9016	92	ND	784	8	ND	9800	8.46	0	100	2	136
14	.035	0.14	18	1	31400	100	ND	0	0	ND	31400	3.50	100	0	3	334
15	.035	0.21	19	1	18000	100	ND	0	0	ND	18000	3.20	60	40	3	176
16	.036	0.38	13	ND	13727	78	5.83	3780	22	7.10	17507	7.08	1	99	23	348
17	.038	0.13	18	1	12087	79	ND	3213	21	ND	15300	3.55	30	70	3	181
18	.040	0.20	19	1	16393	97	ND	507	3	ND	16900	2.60	80	20	2	138
19	.040	0.32	16	1	26211	90	6.21	2934	10	5.69	29145	7.50	1	99	15	361
20	.041	0.60	24	2	10395	64	3.19	5844	36	4.99	16239	4.59	11	89	7	720
21	.041	0.80	14	1	37572	100	5.20	85	0	5.50	37657	4.96	4	96	11	960
22	.041	0.49	4	1	22978	87	3.00	3515	13	4.00	26493	3.58	3	97	18	720
23	.043	0.47	24	ND	13379	88	3.48	1766	12	4.07	15145	3.39	49	51	9	678
24	.044	0.57	13	1	40560	99	4.88	348	1	5.33	40908	5.75	0	100	10	920
25	.045	0.33	15	1	31752	98	ND	648	2	ND	32400	3.67	ND	ND	2	342
26	.046	0.60	18	2	19740	84	ND	3760	16	ND	23500	4.50	0	100	4	808
27	.047	0.32	17	1	18700	85	ND	3300	15	ND	22000	4.25	0	100	2	332
28	.047	0.29	23	1	15105	95	ND	795	5	ND	15900	3.75	50	50	2	246
29	.047	0.61	24	2	12409	55	2.83	10072	45	4.58	22481	3.63	19	81	6	686
30	.050	0.25	23	1	17472	96	ND	728	4	ND	18200	3.05	60	40	3	225
31	.051	0.57	18	2	13057	86	ND	2125	14	ND	15182	4.25	0	100	5	515
32	.052	0.53	26	ND	8190	75	4.08	2752	25	5.67	10942	4.08	14	86	21	400
33	.054	0.14	18	1	28800	100	ND	0	0	ND	28800	3.00	100	0	2	134
34	.054	0.35	13	ND	13449	69	4.10	6127	31	5.50	19576	5.00	1	99	24	359
35	.055	0.31	17	1	20040	96	ND	835	4	ND	20875	5.38	0	100	3	340
36	.056	0.57	26	ND	11970	79	3.67	3249	21	4.25	15219	4.33	4	96	22	312
37	.062	0.22	15	2	20443	90	ND	2271	10	ND	22714	4.86	0	100	2	231
38	.068	0.44	15	1	22800	95	ND	1200	5	ND	24000	4.05	20	80	3	313
39	.083	0.26	15	2	15991	95	ND	842	5	ND	16833	4.83	0	100	3	177
40	.084	1.00	24	ND	5595	75	3.81	1840	25	4.75	7436	3.95	43	57	8	891
41	.087	0.50	22	2	5849	75	3.10	1910	25	4.50	7759	4.30	11	89	19	390
42	.103	0.71	2	1	7645	65	2.14	4093	35	2.79	11738	2.43	25	75	17	340
Av.	**.045**	**0.38**	**15**	-	**19221**	**88**	**3.88**	**2112**	**12**	**4.57**	**21333**	**4.63**	**18**	**82**	-	**410**

[1]Prod = Productivity in hectares per productive man hour.
[2]Temp = Average temperature in °Celsius on the day of observation.
[3]Hist. = History of the site: 1- Softwood cut 2 - Mixedwood cut 3 - old field.
[4]Density = All trees over 30 cm in height.
[5]Operator = Each operator was assigned a number: 1 - 5 => Commercial Safety College Instructors, 6 - 24=> average woods worker.
[6]Observations = Number of activity observations taken at 30 second intervals throughout the work day.
[7]ND = No data.

APPENDIX II

Definitions of work activities recorded during the time studies.

Productive Activities:

Felling Preparation - Deciding which trees to leave as crop trees.

Felling - Felling trees between the crop trees.

Freeing Hung-up Trees - Includes all activities required to free hung-up trees and lay them on the ground.

Limbing and Slashing - Removing some branches, and cutting and slashing the tree so it will lie close to the ground.

Moving - Moving during productive activities only.

Other - Productive activities other than the preceding categories, such as freeing jammed saws, moving brush and helping co-workers.

Non-productive Activities:

Breaks - Personal breaks.

Saw Maintenance - Routine saw maintenance including refuelling, oiling and filing. Includes moving to carry out these activities.

Saw Repair - Repairing the chainsaw, including moving.

Other - Other non-productive activities not listed, such as looking for lost/misplaced equipment.

Other:

Lunch - Formal lunch break. The time taken for formal lunch breaks was not considered as part of the work day.

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